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TOXICOLOGIC GAS EVALUATION OF THE UTILITY TACTICAL TRANSPORT AIRCRAFT SYSTEM (UH-60)

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By

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Accumulation of toxic gases in the aircraft environment can produce a critical operational hazard for the aircrew. In addition to obvious symptoms, such as burning and irritation of mucous membranes and difficulty in breathing, other more subtle effects are noted as a general decrement in performance. This study evaluates toxic gas accumulation as a result of aircraft engine operation and toxic products generated by armament/weapons firing in the Utility Tactical Transport Aircraft System (Sikorsky UH-60) helicopter. On-board mass spectrographic analysis was utilized to identify toxic compounds during a detailed

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SUMMARY

The accumulation of toxic gases in US Army combat and combat support aircraft presents a significant hazard for the aircrew in addition to the combat forces and aeromedical evacuation patients being transported. The US Army Aeromedical Research Laboratory is conducting an on-going evaluation of the cockpit and cabin environment of current and future helicopter and fixed wing aircraft. Toxic product accumulation evaluation during actual flight with weapons firing presents a difficult technicologic challenge. This study of toxic gases due to aircraft engine operation and weapons firing demonstrates adequate ventilation for the compounds carbon monoxide, nitrogen dioxide, nitric oxide, sulfur dioxide, and hydrogen cyanide. Single samples of hydrogen sulfide demonstrate instantaneous toxic levels. Biochemical and analytical techniques are being refined to further evaluate on-line, in-flight hydrogen sulfide levels in US Army aircraft under actual combat conditions.

STANLEY C. KNAPP
Colonel, MC
Commanding

TOXICOLOGIC GAS EVALUATION OF THE UTILITY TACTICAL TRANSPORT AIRCRAFT SYSTEM (UH-60)

INTRODUCTION

During the period 12-14 April 1977, the US Army Aeromedical Research Laboratory (USAARL) Biochemistry Branch of the Aviation Medicine Research Division evaluated toxicologic gases related to the operation of the Sikorsky Utility Tactical Transport Aircraft System (UTTAS) UH-60 aircraft at the request of the US Army Developmental Test Activity (USADTA) by Letter, STEBG-TD, 4 Mar 77, subject: Request for Personnel and Equipment.

METHOD

As representative examples of toxic gases which would possibly accumulate in the aircraft during typical operational conditions, carbon monoxide (CO) and nitrogen dioxide/nitric oxide (NO_2/NO) levels were monitored continuously and quantified during aircraft tests. In addition, an on-board Mass Spectrometer was used to produce immediate mass spectral data in order to analyze rapidly decaying toxic compounds. Samples were also taken in sealed nonreactive containers for later in-laboratory analysis using a high resolution, high sensitivity JEOL D100 Mass Spectrometer. The evaluation was divided into two phases: (1) accumulation of toxic gases from the aircraft engines and (2) generation of toxic gases as a result of weapons firing.

Both phases were conducted under a variety of conditions which, according to experimental design, would encompass as many operational procedures as the UTTAS would be anticipated to perform.

RESULTS

Aircraft Engine Evaluation. Tables I and II represent the gases detected in the aircraft as a function of selected aircraft maneuvers. The reference for this test was Military Standard 800 for carbon monoxide evaluation in military aircraft.[1]

TABLE I

Carbon Monoxide Evaluation of Aircraft Engines (Ground Tests)

Heading Relative To Wind Direction	CO Measured Parts Per Million (ppm)	Maximum Standard Parts Per Million (ppm)[1]
0	<1	1200
90°	2	1200
180°	1	1200
270°	1	1200

Wind velocity was reported as 1 m.p.h.

TABLE II

Carbon Monoxide Evaluation of Aircraft Engines (Flight Tests)

Condition	CO Measured (ppm)	Maximum Standard[1] (ppm)
Normal Cruise Power	<1	1200
Full Military Power Climb	4	1200
Aircraft Circling	1	1200
Hovering	5	1200
Backward Flight	1	1200
Lateral Flight	1	1200

Gun Gas Evaluation. Table III is included as an example of the type of firing format that was used. During the test series, airspeed (AS) was varied from 40 to 100 knots. Degree of offset by the right and left gunners was effected through a representative number of positions while conditions such as number of rounds fired and status of the aircraft ventilation system were varied. All tests were conducted at an altitude of 1,000 feet.

Carbon monoxide (CO) was monitored continuously during the test series and was found to vary from 0 to 20 parts per million (ppm). The worst case situation occurred at the slowest airspeed tested (40 knots) with both guns at maximum firing rate. However, the CO level did not exceed the Occupational Safety and Health Administration (OSHA) standards in any combination of conditions.[2] Nitric oxide and nitrogen dioxide (NO/NO_2) were also monitored continuously and no detectable levels were found.

Mass spectrographic (MS) analysis revealed the gases presented in Table IV.

TABLE III

FIRING PROTOCOL

Event No.	Pilot				Left Gunner					Right Gunner				
	Aircraft Flight Conditions				Subsystem		Target			Subsystem		Target		
	*AS(kts)	Alt(Ft)	•D/N	Special	Type	Rounds	Type	Range(mtr)	Offset	Type	Rounds	Type	Range(mtr)	Offset
1		1000	D	Vent OFF/Toxicology	--	--	--	--	--	7.62	45	NA	Max	0
2		1000	D	Vent OFF/Toxicology	--	--	--	--	--	7.62	45	NA	Max	Max-R
3		1000	D	Vent OFF/Toxicology	--	--	--	--	--	7.62	45	NA	Max	Max-L
4		1000	D	Vent ON/Toxicology	--	--	--	--	--	7.62	45	NA	Max	Max-U
5		1000	D	Vent ON/Toxicology	--	--	--	--	--	7.62	45	NA	Max	Max-U/L
6		1000	D	Vent ON/Toxicology	--	--	--	--	--	7.62	45	NA	Max	Max-U/R
7		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	0	--	--	--	--	--
8		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	Max-R	--	--	--	--	--
9		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	Max-L	--	--	--	--	--
10		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U	--	--	--	--	--
11		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U/L	--	--	--	--	--
12		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U/R	--	--	--	--	--
13		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	0	7.62	45	NA	Max	0
14		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	Max-R	7.62	45	NA	Max	Max-L
15		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	Max-L	7.62	45	NA	Max	Max-R
16		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U	7.62	45	NA	Max	Max-U
17		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U/L	7.62	45	NA	Max	Max-U/R
18		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U/R	7.62	45	NA	Max	Max-U/L
19		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	0	7.62	45	NA	Max	0
20		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	Max-R	7.62	45	NA	Max	Max-R
21		1000	D	Vent OFF/Toxicology	7.62	45	NA	Max	Max-L	7.62	45	NA	Max	Max-L
22		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U	7.62	45	NA	Max	Max-U
23		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U/L	7.62	45	NA	Max	Max-U/L
24		1000	D	Vent ON/Toxicology	7.62	45	NA	Max	Max-U/R	7.62	45	NA	Max	Max-U/R

*AS = Air Speed
•D/N = Day/Night

TABLE IV

MASS SPECTROGRAPHIC ANALYSIS OF GUN GASES*

Gas	Sample 1 (ppm)	Sample 2 (ppm)	OSHA Standard Based on 8 Hr/ Day, 40 Hr/Week, Weighted Exposure Level (ppm)[2]
NO	None detected	None detected	5
NO_2	None detected	None detected	5
SO_2	24	8.5	5
HCN	18	21.0	10
H_2S**	126	63.0	50

*Accuracy is ± 25%.
**OSHA standards only allow one 10 minute exposure of 50 ppm H_2S in any 8 hour period as opposed to the other gases in the table which are based on weighted averages.

The two samples analyzed were collected during the worst case situation described above. Trace quantities of other compounds were noted from the mass spectra generated but could not be positively identified due to the complex nature of the mixture. The only compound that was present in significant quantity is described as demonstrating a primary mass to change (m/e) ratio peak at atomic mass unit (amu) 57 and is probably Allyl alcohol, 2 Butane-1-ol or a product having a similar fragmentation pattern.

Mass spectrographic identification of low molecular weight compound mixtures was accomplished through peak matching and cracking patterns of known compounds. Quantification was achieved by using Argon, which has a known concentration in air (.94% or 940 ppm) as an internal reference, and comparing selected peak heights.[3,4] The sensitivity of Argon and that of the unknown is used to establish a ratio correction factor. The sensitivities are usually referenced to n-butane and are found in the Cornu compilation of mass spectral data.[5] Fragmentation patterns are also determined from these tables. The formula for the general quantitation calculation is:

$$C_X = \frac{S_A}{S_X} \times \frac{P_X}{P_A} \times C_A$$

Where C_X = Concentration of unknown
S_A = Sensitivity of Argon
S_X = Sensitivity of unknown
P_X = Peak height of unknown
P_A = Peak height of Argon
C_A = Concentration of Argon in air (940 ppm)

DISCUSSION

Significant gas levels were identified according to current OSHA standards. All gases that were detected with the exception of hydrogen sulfide (H_2S) were in the category of 8 hour weighted exposure compounds. An individual may thus experience a maximum exposure level in a relatively short period of time if the average stated level is not exceeded in an 8 hour period. Several periods of exposure would also be allowed if the cumulative dose did not exceed the average 8 hour value.

The other category which is identified as ceiling concentration is more restrictive in that a one time only exposure of a certain level for a stated number of minutes is allowed for any 8 hour period. H_2S is in the latter category.

It is felt that the aircraft ventilation system could not be adequately evaluated because of safety considerations dictated by the firing range. The rapid forward movement of the aircraft and the accompanying forced air ventilation through the gunner's door probably created an override situation which could have masked any contribution by the aircraft's vent system. A low hover, maximum fire maneuver would probably have permitted a definitive evaluation in this case.

SUMMARY

During the test series, no significant accumulation of carbon monoxide was experienced.

Although present in significant quantity, the levels of sulfur dioxide (SO_2) and hydrogen cyanide (HCN) were not interpreted as excessive because they are in the OSHA 8 hour weighted exposure category.[2] For example, a gunner would have to be exposed to over 100 minutes of continuous firing in one 8 hour period to exceed the stated safe level of SO_2 when the worst case is used as a model.

H_2S is in the OSHA ceiling concentration category. Due to the one time only exposure restriction imposed by this category, H_2S concentrations were interpreted to have exceeded the safe limits as defined by OSHA regulations.

CONCLUSION

During the test series, there was no significant difference in gas concentration that could be attributed to the vent system being open or closed. Future tests should include specific design to evaluate the helicopter ventilation system in a low hover, maximum fire situation.

H_2S concentrations were obtained on two occasions exceeding OSHA limits. Time weighted exposure could not be quantified due to sampling limitations. H_2S concentrations should be evaluated independently in order to determine if the findings in this study represent sustained high levels or a transient condition.

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REFERENCES

1. "Procedure for Carbon Monoxide Detection and Control in Aircraft," Military Standard 800, United States Government Printing Office, Washington, D. C., 21 July 1958.

2. "Occupational Safety and Health Administration Standards," Part 1910, Subpart 2, Section 1910.1000, Table 21, pp 642.2-642.13, Government Printing Office, Washington, D. C., 1976.

3. Jeffery, P. G. and Kipping, P. J., "Gas Analysis by Gas Chromatography," p. 102, Macmillan Company, 1964.

4. Roboz, John, "Introduction to Mass Spectrometry Instrumentation and Techniques," Interscience 312-320, 1968.

5. Cornu, A. and Massot, R., "Compilation of Mass Spectral Data," Heyden & Son Ltd., Presses Universitaires de France, 1966.

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US Army Aeromedical Research Laboratory, Fort Rucker, Alabama, TOXICOLOGIC GAS EVALUATION OF THE UTILITY TACTICAL TRANSPORT AIRCRAFT SYSTEM (UH-60) by Richard L. Schumaker, MAJ, MSC, and Gary D. Pollard, CPT, MSC; 10 pp, DA Project 3A0 6211 0A 819, Aviation Medicine Research Division. Accumulation of toxic gases in the aircraft environment can produce a critical operational hazard for the aircrew. In addition to obvious symptoms, such as burning and irritation of mucous membranes and difficulty in breathing, other more subtle effects are noted as a general decrement in performance. This study evaluates toxic gas accumulation as a result of aircraft engine operation and toxic products generated by armament/weapons firing in the Utility Tactical Transport Aircraft System (Sikorsky UH-60) helicopter. On-board mass spectrographic analysis was utilized to identify toxic compounds during a detailed series of aircraft operational maneuvers. Carbon monoxide (CO), nitrogen dioxide (N_2O), nitric oxide (NO), sulfur dioxide (SO_2), and hydrogen cyanide (HCN) were within acceptable limits. Hydrogen sulfide (H_2S) was found on random samples to exceed the Occupational Safety and Health Administration (OSHA) standards. Techniques to evaluate H_2S on-line are being developed continuously to quantify this toxic product.

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